

**SSME FMEA/CIL
REDUNDANCY SCREEN**

Component Group: Fuel Turbopumps
 CIL Item: B200-08
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501
 Failure Mode: Fails to transmit torque.

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 4/21/99
 Change #: 1
 Directive #: CCBD ME3-01-5206
 Page: 1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4 1	Turbine unloads and overspeeds with probable blade failure and/or disk burst. Extensive turbine damage from impact and over-temperature may result in loss of hot-gas containment. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A.	1 ME-D1S,M, ME-D1A,C

**SSME FMEA/CIL
DESIGN**

Component Group: Fuel Turbopumps
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Component: High Pressure Fuel Turbopump
Part Number: RS007501
Failure Mode: Fails to transmit torque.

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Page: 1 of 2

Design / Document Reference

FAILURE CAUSE: A: Spline failure (any 1 of 5).

SIX INVOLUTE SPLINES, INVOLVING 7 PARTS (1)(2)(3)(4)(5)(6), TRANSMIT THE TORQUE AND CLAMPING FORCES BETWEEN THE ROTOR COMPONENTS. THE 3 IMPELLERS ARE MANUFACTURED UTILIZING TITANIUM 5A1-2.5Sn (F11) FORGINGS. THIS ALLOY WAS SELECTED FOR ITS STRENGTH, TOUGHNESS, AND FATIGUE PROPERTIES IN HYDROGEN AT CRYOGENIC TEMPERATURES (7). THE MATERIAL IS ANNEALED TO IMPROVE MECHANICAL PROPERTIES. THE DISKS ARE MANUFACTURED UTILIZING TMP WASPALOY FORGINGS AND CRITICAL AREAS ARE GOLD PLATED FOR HYDROGEN ENVIRONMENT EMBRITTLEMENT PROTECTION (7). THIS ALLOY WAS SELECTED FOR ITS STRENGTH AT BOTH CRYOGENIC AND ELEVATED TEMPERATURES AND ITS STRENGTH TO WEIGHT RATIO. THE MATERIAL IS THERMO-MECHANICALLY PROCESSED WHICH CONSISTS OF HOT-COLD WORK FOLLOWED BY A SOLUTION TREATMENT AND AGING TO IMPROVE ELEVATED TEMPERATURE MATERIAL PROPERTIES. THE SLEEVES ARE MANUFACTURED UTILIZING INCONEL 718 BAR. THIS MATERIAL WAS SELECTED FOR ITS STRENGTH, RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING, AND CRYOGENIC DUCTILITY (7). PROTECTION AGAINST HYDROGEN ENVIRONMENT EMBRITTLEMENT IS NOT REQUIRED IN THE SLEEVES CRYOGENIC OPERATING ENVIRONMENT. THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED. THE IMPELLERS AND DISKS GRAIN DIRECTION IS SPECIFIED BY DRAWING REQUIREMENTS TO ACHIEVE MAXIMUM MATERIAL PROPERTIES IN THE DIRECTION OF THE HIGHEST LOADS. EACH DISK AND IMPELLER IS INDIVIDUALLY SPUN AS PART OF THE MANUFACTURING PROCESS TO VERIFY THE PARTS STRUCTURAL INTEGRITY. DRY FILM LUBRICANT IS APPLIED TO ALL SPLINES AT ASSEMBLY TO PREVENT FRETTING AND TO REDUCE FRICTION FOR DISASSEMBLY. THE INSIDE DIAMETER SPLINES OF THE SLEEVES MATE WITH THE OUTSIDE DIAMETER SPLINES TO PILOT THE IMPELLERS AND DISK. THE SLEEVES BETWEEN IMPELLERS ALSO MATE WITH THE PUMP INTERSTAGE SEALS (8). A CHROME PLATED SURFACE ON THE SLEEVE BETWEEN THE THIRD-STAGE IMPELLER AND SECOND-STAGE DISK PROVIDES THE SEALING SURFACE FOR THE LIFT-OFF SEAL (9). THE SLEEVES ARE CONFIGURED TO PERMIT RECIRCULATION FLOW THROUGH THE IMPELLER HUBS. THE SLEEVES PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH SINCE THEY ARE NOT FRACTURE CRITICAL PARTS, EXCEPT FOR THE FIRST, SECOND, AND THIRD-STAGE IMPELLERS AND THE SECOND-STAGE DISK WHICH WERE CLEARED BY CRITICAL INITIAL FLAW SIZE DETECTABILITY (10). THE FACTOR OF SAFETY ON BURST FOR THE IMPELLERS HAS BEEN VERIFIED BY DESIGN VERIFICATION TESTS (11). THE TURBINE DISKS HAVE BEEN DESIGN VERIFICATION TESTED FOR PRIMARY STRESS, LOW CYCLE FATIGUE LIFE, AND VIBRATION CHARACTERISTICS (12)

(1) R0019228; (2) RS007555; (3) RS007556; (4) RS007583; (5) RS007584; (6) RS007510; (7) RSS-8580-10; (8) RS007531; (9) R0019230; (10) NASA TASK 117; (11) RSS-404-36; (12) RSS-404-34 RSS-404-9

**FAILURE CAUSE: B: Curvic coupling failure.
C: Turbine disk failure.**

THE FIRST-STAGE (1) AND SECOND-STAGE (2) DISKS ARE MANUFACTURED UTILIZING WASPALOY FORGINGS (3). THIS ALLOY WAS SELECTED FOR ITS STRENGTH AND DUCTILITY AT BOTH CRYOGENIC AND ELEVATED TEMPERATURES AND ITS STRENGTH TO WEIGHT RATIO. THE MATERIAL IS THERMO-MECHANICALLY PROCESSED WHICH CONSISTS OF HOT-COLD WORK FOLLOWED BY A SOLUTION TREATMENT, STABILIZING, AND AGING TO IMPROVE HIGH TEMPERATURE MATERIAL PROPERTIES. THE GRAIN DIRECTION IS SPECIFIED BY DRAWING REQUIREMENTS TO ACHIEVE MAXIMUM MATERIAL PROPERTIES IN THE DIRECTION OF THE HIGHEST LOADS. EACH DISK CONTAINS 40 TEETH, AND WHEN MATED TO EACH OTHER FORM THE CURVIC COUPLING. THE DISKS ARE BOLTED TOGETHER WITH 10 BOLTS (4), AND NUTS (5) WHICH ARE LOCKED IN PLACE BY 5 LOCKS (6) (EACH LOCK RETAINS TWO NUTS). BALANCE WEIGHTS ARE SECURED BENEATH THE NUTS AT ASSEMBLY TO FINAL BALANCE THE ROTOR (7). THE BOLTS DO NOT TRANSMIT TORQUE BETWEEN THE DISKS. TORQUE TRANSMISSION OCCURS ONLY AT THE CURVIC COUPLING. CRITICAL PARTS OF THE DISKS ARE GOLD-PLATED TO PROTECT THEM FROM HYDROGEN ENVIRONMENT EMBRITTLEMENT. THE DISKS ARE COOLED DURING OPERATION BY HYDROGEN FLOW TO MAINTAIN MECHANICAL PROPERTIES. EACH DISK IS INDIVIDUALLY SPUN PER DRAWING REQUIREMENTS AS PART OF THE MANUFACTURING PROCESS TO VERIFY ITS STRUCTURAL INTEGRITY. A CONTROL CURVIC COUPLING TOOL IS UTILIZED TO VERIFY THE TOOTH BEARING PATTERN MEETS DRAWING REQUIREMENTS AFTER MACHINING. MATERIAL IS REMOVED FROM THE BALANCE RIBS TO FINAL BALANCE THE DISK (8). THE TURBINE DISKS HAVE BEEN DESIGN VERIFICATION TESTED FOR PRIMARY STRESS, LOW CYCLE FATIGUE LIFE, AND VIBRATION CHARACTERISTICS (9). THE FIRST AND SECOND-STAGE DISKS PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH BY CRITICAL INITIAL FLAW SIZE DETECTABILITY (10).

(1) RS007517; (2) RS007510; (3) RSS-8580-10; (4) RS007580; (5) RS007582; (6) RS007581; (7) R0019998; (8) RL000351; (9) RSS-404-34 RSS-404-9; (10) NASA TASK 117

Component Group: Fuel Turbopumps
CIL Item: B200-08
Component: High Pressure Fuel Turbopump
Part Number: RS007501
Failure Mode: Fails to transmit torque.

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Page: 2 of 2

Design / Document Reference

FAILURE CAUSE: D: Turbine bolt failure.

THE TURBINE BOLTS (1) ARE MANUFACTURED UTILIZING A-286 CRES BAR (2). THIS ALLOY WAS SELECTED FOR ITS RESISTANCE TO HIGH-PRESSURE HYDROGEN DEGRADATION, MECHANICAL PROPERTIES AT CRYOGENIC TEMPERATURE, AND RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING. THE MATERIAL IS SOLUTION-TREATED, COLD-WORKED, AGED, AND COLD-WORKED TO IMPROVE MECHANICAL PROPERTIES. TEN BOLTS ARE USED TO SECURE THE TWO DISKS TOGETHER AND ARE RETAINED BY 10 A-286 CRES NUTS (3) AND 5 NUT LOCKS (4) (EACH LOCK RETAINS 2 NUTS). THE NUT ALLOY IS SOLUTION-TREATED AND AGED TO IMPROVE MECHANICAL PROPERTIES. THE NUTS ARE LUBRICATED TO REDUCE FRICTIONAL FORCES WITH THE BOLT THREADS. THE STUDS ARE STRETCHED AT ASSEMBLY PER DRAWING REQUIREMENTS TO ATTAIN THE REQUIRED CLAMPING LOAD. THE BOLTS DO NOT TRANSMIT TORQUE BETWEEN THE DISKS. TORQUE TRANSMISSION OCCURS ONLY AT THE DISK CURVIC. THE DISKS, NUTS, AND BOLTS ARE COOLED BY HYDROGEN FLOW DURING OPERATION TO MAINTAIN MATERIAL PROPERTIES. THE BOLTS AND NUTS ARE NOT TIME-HISTORY TRACKED AND HAVE INFINITE ALLOWABLE LIFE (5). THE TURBINE BOLT PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/IDE FLAW GROWTH SINCE IT IS NOT A FRACTURE CRITICAL PART (6).

(1) RS007580; (2) RSS-8580-10; (3) RS007582; (4) RS007581; (5) RL00532, CP320R0003B; (6) NASA TASK 117

FAILURE CAUSE: E: Stud failure.

THE STUD (1) IS MANUFACTURED UTILIZING INCONEL 718 BAR (2). AN INCONEL 718 ANTI-VORTEX BAFFLE (3) IS THREADED TO THE TURBINE END AND LOCKED WITH AN INCONEL 718 PIN (4). INCONEL 718 WAS SELECTED FOR ITS STRENGTH AND DUCTILITY AT CRYOGENIC TEMPERATURES. IT IS RESISTANT TO CORROSION AND STRESS CORROSION CRACKING, AND IN CRYOGENIC ENVIRONMENT, IT DOES NOT REQUIRE PROTECTION TO AVOID HYDROGEN ENVIRONMENT EMBRITTLEMENT (2). THE MATERIAL IS SOLUTION-TREATED AND AGE-HARDENED. THE ANTI-VORTEX BAFFLE ASSURES ORDERLY FLOW OF THE COOLANT TO THE TURBINE. THREE SETS OF RAISED LANDS SPACED ALONG THE LENGTH OF THE STUD (THE BOLT) PROVIDE CLOSE RADIAL CLEARANCE WITH THE FIRST AND SECOND STAGE IMPELLER BORES (4) TO LIMIT DEFLECTION OF THE STUD. FIRST AND SECOND STAGE IMPELLER BORE WEAR IS CONTROLLED BY UTILIZING REPLACEABLE INSERTS (5). FIRST AND SECOND STAGE IMPELLER INSERTS ARE MANUFACTURED FROM COBALT BASE L-605 (STELITE 25) FORGING (6). THIS ALLOY WAS SELECTED FOR ITS TOUGHNESS, RESISTANCE TO GALLING WITH THE INCONEL 718 STUD, RESISTANCE TO HYDROGEN EMBRITTLEMENT AND RESISTANCE TO THERMAL SHOCK (7). THE MATERIAL IS COLD WORKED TO DEVELOP THE REQUIRED HARDNESS (8). IMPELLER BORE INSERTS ARE PERIODICALLY INSPECTED FOR WEAR (9). IMPELLER BORE INSERTS WITH WEAR IN EXCESS OF SPECIFICATION LIMITS ARE REPLACED (10). EACH LAND IS INTERRUPTED AROUND ITS CIRCUMFERENCE IN THREE PLACES TO PERMIT FLOW OF HYDROGEN AXIALLY ALONG THE STUD. THE STUD IS THREADED INTO THE SECOND-STAGE DISK (11) AND CAPTURES A STATIC SEAL (12) TO PREVENT HYDROGEN LEAKAGE. AFTER ASSEMBLY WITH THE IMPELLERS AND SLEEVES, THE STUD IS STRETCHED TO BOTTOM THE ROTOR STACK. A SHAFT NUT IS INSTALLED AND LOCKED IN PLACE ON THE END OF THE SHAFT ONCE THE REQUIRED STUD STRETCH IS ACHIEVED. THE STUD DOES NOT TRANSMIT TORQUE DURING OPERATION. TORQUE TRANSMISSION OCCURS ONLY AT THE IMPELLER SLEEVES. THE STUD PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/IDE FLAW GROWTH SINCE IT IS NOT A FRACTURE CRITICAL PART (13).

(1) RS007514; (2) RSS-8580-10; (3) R0019256; (4) R0019226, RS007555; (5) R0019226-023, RS007555-025; (6) AMS 5759; (7) MPR-91-1426; (8) R0019226, RS007555; (9) RL00050-04, RL00528, RL0004-302; (10) RL00528, RL0004-302; (11) RS007510; (12) RES1190; (13) NASA TASK 117

FAILURE CAUSE: ALL CAUSES

THE HIGH AND LOW CYCLE FATIGUE LIFE FOR THE SLEEVES, STUD, IMPELLERS, DISKS, AND THE TURBINE BOLTS MEET CEI REQUIREMENTS (1). SECOND-STAGE DISCS NOT MEETING CEI LIFE REQUIREMENTS ARE ADDRESSED BY MAJOR WAWER (5). THE MINIMUM FACTORS OF SAFETY FOR THESE PARTS MEET CEI REQUIREMENTS (2). THE ROTATING ASSEMBLY HAS BEEN DESIGN VERIFICATION TESTED FOR SPRING RATE (LOAD DEFLECTION) AND NATURAL FREQUENCY (VIBRATION) DETERMINATION (3). REUSE OF PARTS DURING OVERHAUL IS CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (4).

(1) RL00532, CP320R0003B; (2) RSS-8546-16, CP320R0003B; (3) RSS-404-17; (4) DL00528; (5) DAR 2232

SSME FMEA/CIL INSPECTION AND TEST

Component Group: Fuel Turbopumps
 CIL Item: B200-08
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501
 Failure Mode: Fails to transmit torque.

Prepared: D. Early
 Approved: T. Nguyen
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Page: 1 of 4

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	FIRST-STAGE IMPELLER SECOND-STAGE IMPELLER THIRD-STAGE IMPELLER		R0019226 RS007555 RS007556
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-152
		THE FORGING IS PENETRANT AND ULTRASONIC INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116 RA0115-012
		THE FORGINGS GRAIN DIRECTION IS VERIFIED PER DRAWING REQUIREMENTS.	RS007586
		THE IMPELLER SPIN TEST VERIFIES MAXIMUM GROWTH PER DRAWING AND SPECIFICATION REQUIREMENTS.	R0019226 RS007555 RS007556 RL00075
		THE IMPELLER IS PENETRANT INSPECTED AFTER SPIN TEST PER SPECIFICATION REQUIREMENTS	RA0115-116
	SURFACE FINISH	DRY FILM LUBRICATION IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0112-002
	ASSEMBLY INTEGRITY	SPLINE MEASUREMENTS ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	R0019226 RS007555 RS007556 RA0115-143
	OVERHAUL	THE IMPELLERS ARE INSPECTED AT OVERHAUL PER SPECIFICATION REQUIREMENTS	RF0004-302
	FIRST AND SECOND STAGE SLEEVES THIRD-STAGE SLEEVE		RS007583 RS007584
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-153
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	SURFACE FINISH	SLEEVE HARD CHROME PLATING IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007584 RA1609-002
		DRY FILM LUBRICATION IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0112-002
	ASSEMBLY INTEGRITY	SPLINE MEASUREMENTS ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007583 RS007584 RA0115-143
	THE SLEEVES AND IMPELLERS ARE MATCH-MACHINED PER DRAWING REQUIREMENTS.	RS007501	
SECOND-STAGE DISK		RS007510	
MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS, GRAIN DIRECTION IS VERIFIED PER DRAWING REQUIREMENTS. TENSILE SPECIMEN TEST IS PERFORMED PER DRAWING REQUIREMENTS.	RB0170-182 RS007516	

Component Group: Fuel Turbopumps
 CIL Item: B208-08
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501
 Failure Mode: Fails to transmit torque.

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 Page: 2 of 4

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	MATERIAL INTEGRITY	SPIN TEST IS PERFORMED PER DRAWING REQUIREMENTS.	RS007510
		THE DISK IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS BEFORE AND AFTER SPIN TEST.	RA0115-116
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-182
	SURFACE FINISH	DRY FILM LUBRICATION IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0112-002
	ASSEMBLY INTEGRITY	SPLINE DIMENSIONS ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS	RS007510 RA0115-143
B, C	DISK ROTOR FIRST-STAGE		RS007517
	DISK ROTOR SECOND-STAGE		RS007510
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-182
		THE GRAIN DIRECTION IS VERIFIED PER DRAWING REQUIREMENTS	RS007516
		TENSILE SPECIMEN TEST IS PERFORMED PER DRAWING REQUIREMENTS.	
		THE SPIN TEST IS PERFORMED PER DRAWING REQUIREMENTS	RS007517 RS007510
		THE DISK IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS BEFORE AND AFTER SPIN TEST.	RA0115-116
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS	RB0170-182
	SURFACE FINISH	THE GOLD PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS	RA1109-009
		TURBINE END COMPONENTS ARE BORESCOPE INSPECTED FOR EVIDENCE OF LOSS OF GOLD PLATING PRIOR TO EACH FLIGHT.	OMRSD V41BU0.075
	ASSEMBLY INTEGRITY	THE CURVIC COUPLING TOOTH BEARING PATTERN IS VERIFIED PER DRAWING REQUIREMENTS	RS007517 RS007510

CrL Item: Fuel Turbopumps
 Component: B200-08
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 Page: 3 of 4

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
B, C	ASSEMBLY INTEGRITY	FIR-TREE BROACHING IS VERIFIED BEFORE AND AFTER GOLD PLATING PER DRAWING REQUIREMENTS	RS007517 RS007510
		SECOND-STAGE SPLINE DIMENSIONS ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007510 RA0115-143
D	BOLT LOCK NUT		RS007580 RS007581 RS007582
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0160-014 QQS-788 AMS-5737
		BOLT IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
		NUT IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	
	HEAT TREAT	BOLT HARDNESS IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0160-014
	SURFACE FINISH	APPLICATION OF MOLYKOTE TO BOLT IS VERIFIED PER DRAWING REQUIREMENTS	RS007501
ASSEMBLY INTEGRITY		BOLT STRETCH IS VERIFIED PER DRAWING REQUIREMENTS.	RS007501
		THE LOCK DEFORMATION IS VERIFIED PER DRAWING REQUIREMENTS.	
E	STUD ASSEMBLY		RS007514
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENT.	RB0170-153
		THE STUD IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENT.	RA0115-116
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0611-020 RS007514
		HARDNESS IS VERIFIED PER DRAWING REQUIREMENTS.	RS007514
	ASSEMBLY INTEGRITY	TORQUE AND STRETCH ARE VERIFIED PER DRAWING REQUIREMENTS.	RS007501
		STUD LUBE IS VERIFIED PER DRAWING REQUIREMENTS.	
	OVERHAUL	THE IMPELLER HUB AND BORE ARE VISUALLY INSPECTED PER SPECIFICATION REQUIREMENTS AT INTERVALS DEFINED BY MAJOR WAIVER.	RF0004-302 DAR 2061
	IMPELLER INSERT IMPELLER INSERT		R0019226-023 RS007555-025
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	AMS 5759
	MATERIAL HARDNESS IS VERIFIED PER DRAWING REQUIREMENTS	R0019226 RS007555	
	INSERTS ARE PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	RA0115-116	

B - 48

Component Group: Fuel Turbopumps
 CIL Item: B200-06
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501
 Failure Mode: Fails to transmit torque.

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 Directive #: CCBO ME3-01-5206
 Page: 4 of 4

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
F	OVERHAUL	IMPELLER INSERTS ARE INSPECTED FOR BORE WEAR PER SPECIFICATION REQUIREMENTS.	RF0004-302
ALL CAUSES	HPFTP		RS007501
	ASSEMBLY INTEGRITY	<p>THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT AND REPLACEMENT OF USAGE ITEMS AS APPLICABLE, PER OVERHAUL CLASSIFICATION.</p> <p>OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT FIRE TESTING AND 2ND E & M TESTS ON INSPECTIONS.</p> <p>TORQUE CHECKS ARE PERFORMED PRIOR TO EACH FLIGHT.</p> <p>DATA FROM PREVIOUS FLIGHT OR HOT FIRE IS REVIEWED FOR PROPER TURBOPUMP OPERATION/PERFORMANCE. (LAST TEST)</p>	<p>RL00528 RA0115-116</p> <p>RL00050-04 RL00056-05 RL00056-07 RL00461</p> <p>OSMRD V41D50.020 MSFC PLN 1228</p>

B - 49

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21/88/308 and Rocketdyne letter 88RC09751
 Operational Use: Not Applicable.

SSME FMEA/CIL
FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

Component Group: Fuel Turbopumps
 Item Name: High Pressure Fuel Turbopump
 Item Number: B200
 Part Number: RS007501

Prepared: D. Early
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 Change #: 2
 Directive #: CCBD ME3-01-5208

Page: 1 of 2

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. B200-15 RS007502; CAUSE A, B200-24; RS007605; CAUSE A THE INNER AND OUTER BEARING RACES ARE EDDY CURRENT INSPECTED PER RL00743.	BEARING RACES RECEIVED FROM SUPPLIER SPLIT BALL BEARING INCORPORATED RECEIVED NO GENERAL EDDY CURRENT INSPECTION	GENERAL EDDY CURRENT INSPECTION OF RACES REPLACES TYPE IVC IN PENETRANT INSPECTION IN DETECTING SURFACE FLAWS USE AS IS RATIONALE: 1. RACES SUPPLIED BY SPLIT BALL BEARING INCORPORATED RECEIVED 10X VISUAL AND TYPE IVC PENETRANT INSPECTION INSTEAD OF GENERAL EDDY CURRENT INSPECTION. FLAW DETECTABILITY RELIABILITY LEVELS BETWEEN PENETRANT AND GENERAL EDDY CURRENT INSPECTIONS ARE 0.060 AND 0.057 RESPECTIVELY.	SEE DAR 2745 FOR VARIANT PART SERIAL NUMBERS.
2. B200-13 RS007527, RS007532, CAUSE A & B. B200-26; RS007532; CAUSE B. DIFFUSER HIDDEN SURFACES ARE PENETRANT INSPECTED PER RL00343.	SOME DIFFUSERS MAY NOT RECEIVE THE POST PROOF TEST HIDDEN SURFACE IIP PENETRANT INSPECTION	USE AS IS RATIONALE 1. IMPLEMENTATION OF HIDDEN SURFACE INSPECTION REQUIREMENT IS NOT A RESULT OF AN OBSERVED HARDWARE ANOMALY BUT AS A RESULT OF ROCKETDYNE'S STAND DOWN.	SEE DAR 2751 FOR VARIANT PART SERIAL NUMBERS
3 B200-14 CAUSE A, RS007568 B200-21 CAUSE B, RS007568 B200-26 CAUSE A, RS007568 WELD JOINTS RS007568 TABLE B200 HPFT FMEA/CIL WELD JOINTS RS007568 HOUSING CURRENT CONFIGURATION IS THE ONE (1) PIECE "113" CAP, USING FOUR (4) WELDS AND FOUR (4) WELD NUMBERS	SOME HOUSINGS (POSSIBLY TWO) MAY HAVE BEEN FABRICATED WITH THE TWO (2) PIECE "113" CAPS (THIS HAS AN EXTRA WELD: #13 AND THREE EXTRA WELD NUMBERS 13, 68 & 69)	TO REDUCE CONFUSION ON THE DRAWING AND ON THE MANUFACTURING FLOOR	SEE MCR 2524. SAME -113 DASH NUMBER.
4 B200-02; CAUSE A, RS007524 CAUSE B, RS007524; CAUSE C, RS007524	SOME TURBINE BEARING SUPPORTS (RS007524) ARE FABRICATED USING A WELDMENT OF HAYES 188 SHEET METAL INSTEAD OF THE EDM FORGING.	HIGH CYCLE FATIGUE INDUCED INLET SHEET METAL CRACKS DO OCCUR FROM THE OPERATIONAL ENVIRONMENT EXPERIENCED DURING ENGINE OPERATION. THE CRACKING IS CONTROLLED PER THE REQUIREMENTS OF THE SHEET METAL INSPECTION SPECIFICATION (RL00655) WHICH LIMITS THE CRACKING LENGTH, SPACING, AND SHAPE, TO PRECLUDE SHEET METAL PIECES FROM DISLODGING. THE CRITERIA IS BASED ON CRACK GROWTH RATES AND ENGINE TEST EXPERIENCE. ANY CRACKS, WHICH EXCEED THE SPECIFICATION LIMITS, ARE WELD REPAIRED (RF0001-007). THE TURBINE BEARING SUPPORT WITH WELDED SHEET METAL IS LIFE LIMITED BY MAJOR WAIVER DAR 2709.	RS007524-201 AND SUBS.

B-181

Component Group: Fuel Turbopumps
 Item Name: High Pressure Fuel Turbopump
 Item Number: B200
 Part Number: RS007501

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Page: 2 of 2

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
5 B200-18 CAUSE A, B200-17 CAUSE A, B200-18 CAUSE A, B200-19 CAUSE A, B200-22; CAUSE A,B,C,E	SOME LIFT-OFF SEAL HOUSING DRAIN LINES ARE FABRICATED USING INTERSECTING LINE DRILLED HOLES THE HOLE THAT INTERSECTS THE OUTSIDE DIAMETER OF THE HOUSING FLANGE HAS A PLUG INSTALLED. THE PLUG IS THEN WELDED AT THE HOUSING OUTSIDE DIAMETER TO FORM A TIGHT GAS SEAL	LOW CYCLE FATIGUE CRACKING HAS BEEN OBSERVED IN THE PLUG WELD. CRACK INITIATION AND PROPAGATION OCCURS AT SHUTDOWN/COOLDOWN ALL UNITS RECEIVE A STANDARD POST FLIGHT INSPECTIONS BY LEAK CHECK. LEAK CHECK POST FLIGHT WILL DETECT A CRACK PRIOR TO REFLIGHT. POST LEAKAGE AT THE DRAIN LINE IS LIMITED TO 10 SCIM. ALL FLIGHT UNITS WILL CONTINUE TO RECEIVE A LEAK CHECK POST FLIGHT FOR THE DRAIN LINE PLUG WELD UNTIL THE ENTIRE FLEET IS RETROFIT WITH THE EDM DRAIN LINE CONFIGURATION	R0019230-071 AND SUBS.

**SSME FMEA/CIL
WELD JOINTS**

Component Group: Fuel Turbopumps
 CIL Item: B200
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 4/21/99
 Change #: 2
 Directive #: CCBD ME3-01-5206
 Page: 1 of 3

B - 183

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable		Comments
						HCF	LCF	
SHIELD	R0012171	1,24, 28-52	GTAW	II	X			
SHIELD	R0012171	26	GTAW	II				
LIFT-OFF SEAL	R0019230	1, 2	GTAW	II	X			
SHIELD	R0019788	25, 28	GTAW	II				
SHIELD	R0019788	27, 50	GTAW	II	X			
SHIELD	R0019788	51, 52	GTAW	I				
SHIELD	R0019788	53, 55	GTAW	II				
BELLOWS	RS007505	1-4	GTAW	I		X		
BELLOWS	RS007505	5, 6	EBW	I		X		
INLET	RS007512	4	GTAW	I		X		
INLET	RS007512	5-6	GTAW	I				
INLET	RS007512	7-10, 12, 13	GTAW	I				
INLET	RS007512	11	EBW	II				
INLET	RS007512	14, 15	GTAW	I				
INLET	RS007512	16	GTAW	I		X		
BEARING SUPPORT	RS007524	14	EBW	I				
BEARING SUPPORT	RS007524	18	EBW	I	X			
BEARING SUPPORT	RS007524	29, 30	GTAW	I	X	X		
BEARING SUPPORT	RS007524	118	GTAW	I	X			
BEARING SUPPORT	RS007524	119, 121	EBW	I				
BEARING SUPPORT	RS007524	120	GTAW	II	X			
BEARING SUPPORT	RS007524	229-241	GTAW	II	X			
HOUSING	RS007568	75, 223, 228, 230, 298	GTAW	I	X	X	X	
HOUSING	RS007568	14	GTAW	I				
HOUSING	RS007568	48	EBW	I	X	X	X	
HOUSING	RS007568	49	GTAW	I	X			
HOUSING	RS007568	51	GTAW	II	X	X		
HOUSING	RS007568	52	GTAW	II	X			
HOUSING	RS007568	53	EBW	I				

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 Page: 2 of 3

B - 184

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable		Comments
						HCF	LCF	
HOUSING	RS007568	56	EBW	II	X			
HOUSING	RS007568	56	GTAW	II	X			
HOUSING	RS007568	57, 324, 325	GTAW	II				
HOUSING	RS007568	58	GTAW	II	X	X	X	
HOUSING	RS007568	59	EBW	I				
HOUSING	RS007568	74, 229, 297	GTAW	I	X	X	X	
HOUSING	RS007568	76, 77	GTAW	I		X		
HOUSING	RS007568	78-89	GTAW	II	X			
HOUSING	RS007568	90-101	GTAW	II	X			
HOUSING	RS007568	102	GTAW	I	X			
HOUSING	RS007568	139	GTAW	II	X			
HOUSING	RS007568	140	GTAW	II	X			
HOUSING	RS007568	150, 154	GTAW	II	X			
HOUSING	RS007568	174-185	GTAW	II	X			
HOUSING	RS007568	191, 192, 195, 196, 245, 455, 456	GTAW	II	X	X		
HOUSING	RS007568	193, 194, 197-202, 204-207	GTAW	II		X		
HOUSING	RS007568	203, 217, 218, 234, 236	GTAW	II	X	X		
HOUSING	RS007568	212, 213	GTAW	II				
HOUSING	RS007568	214, 215	GTAW	II	X			
HOUSING	RS007568	222, 239	GTAW	I		X		
HOUSING	RS007568	224, 225	GTAW	I		X	X	
HOUSING	RS007568	226, 227	GTAW	I		X		
HOUSING	RS007568	231, 232	GTAW	II	X	X		
HOUSING	RS007568	233	GTAW	II	X			
HOUSING	RS007568	237, 238	GTAW	II				
HOUSING	RS007568	246-248	GTAW	II				
HOUSING	RS007568	326-349	GTAW	II	X			
HOUSING	RS007568	374-397	GTAW	II	X			
HOUSING	RS007568	399	GTAW	I	X	X	X	

Component Group: Fuel Turbopumps
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 Page: 3 of 3

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable		Comments
						HCF	LCF	
HOUSING	RS007568	401-424	GTAW	II	X			
HOUSING	RS007568	425-448	GTAW	II	X			
HOUSING	RS007568	450 (OPT)	GTAW	II				
HOUSING	RS007568	450 (OPT)	EBW	II	X			
HOUSING	RS007568	454	GTAW	II	X			
HOUSING	RS007568	537 (OPT)	GTAW	II				
ROTOR SEAL	RS007588	1	EBW	I				
SEA.	RS007592	25	EBW	II	X			